STATE OF ILLINOIS
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DIVISION OF THE
STATE GEOLOGICAL SURVEY
M. M. LEIGHTON, *Chief*
URBANA

REPORT OF INVESTIGATIONS—NO. 70

PRELIMINARY GEOLOGIC MAP OF PARTS OF THE ALTO PASS, JONESBORO, AND THEBES QUADRANGLES

Union, Alexander, and Jackson Counties

BY

J. MARVIN WELLER AND GEORGE E. EKBLAW

REVISED IN PART FROM MAP BY T. E. SAVAGE

EXPLANATION AND STRATIGRAPHIC SUMMARY

BY

J. MARVIN WELLER

PRINTED BY AUTHORITY OF THE STATE OF ILLINOIS

URBANA, ILLINOIS
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Topographic Mapping in Cooperation with the United States Geological Survey.

This Report is a Contribution of the Division of Stratigraphy and Paleontology.

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(A33296—2M—11-40) November 1, 1940

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PRELIMINARY GEOLOGIC MAP OF PARTS OF THE ALTO PASS, JONESBORO, AND THEBES QUADRANGLES

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INTRODUCTION

PRE-CARBONIFEROUS ROCKS crop out throughout a large area in northern Illinois, but south of Rock Island, La Salle, and Iroquois counties they are brought to the surface in only four small areas upon the borders of the Illinois basin and another on the crest of the La Salle anticline. These are (1) southern Pike, Calhoun, and western Jersey counties, (2) western Monroe County, (3) southern Jackson, western Union, and northern Alexander counties, (4) western Hardin County, and (5) central Douglas County. The geology of Hardin County has been fully described,[1] and the Monroe County area has recently been considered in another publication.[2] This report is concerned with the third of the above areas, which is by far the most interesting and significant because it contains a much thicker exposed stratigraphic section than any of the others and is the only place in Illinois where a fairly complete Devonian sequence can be studied in outcrop. This is of particular importance at present because of the recent rapid and spectacular development of Devonian oil production farther north in Illinois.

The area covered by this report lies west of and adjoins the Dongola, Vienna, and Brownfield quadrangles which have recently been described in a similar publication (fig. 1).[3]

FIELD WORK

The general features of the geology in southwestern Illinois were first worked out and the presence of a thick and unique Devonian section in Jackson, Union, and Alexander counties was first recognized by Worthen and Engleman as the result of field work begun in 1858 and supplemented in subsequent years.[4] Nearly half a century passed, however, before fossils were systematically collected and most of the stratigraphic zones recognized by Savage. These studies furnished material for several publications.[5] Further study of the Jonesboro quadrangle was undertaken by Savage for the Illinois Survey in 1919, the Devonian

[1]Weller, Stuart, and others, The Geology of Hardin County and the adjoining part of Pope County: Illinois Geol. Survey Bull. 41, 1920.

[2]Weller, Stuart, and Weller, J. Marvin, Preliminary Geological Maps of the Pre-Pennsylvanian formations in part of Southwestern Illinois: Illinois Geol. Survey Rept. Inv. 59, 1939.

[3]Weller, Stuart, and Krey, Frank F., Preliminary Geologic Map of the Mississippian Formations in the Dongola, Vienna, and Brownfield Quadrangles; Explanation and Stratigraphic Summary by J. Marvin Weller: Illinois Geol. Survey Rept. Inv. 60, 1939.

[4]Worthen, A. H., and others, Devonian and Silurian Systems: Geological Survey of Illinois, vol. 1, pp. 119-152, 1866.

Worthen, A. H., Geology of Alexander, Union, and Jackson counties: Geological Survey of Illinois, vol. 3, pp. 20-83, 1868.

[5]Savage, T. E., On the lower Paleozoic stratigraphy of southwestern Illinois: Am. Jour. Sci., 4th ser., vol. 25, pp. 431-443, 1908.

———. The Ordovician and Silurian formations in Alexander County, Illinois: Am. Jour. Sci., 4th ser., vol. 28, pp. 509-519, 1909.

———. The Grand Tower (Onondaga) formation of Illinois, and its relations to the Jeffersonville beds of Indiana: Illinois Acad. Sci. Trans., vol. 3, pp. 116-132, 1910.

———. The Thebes sandstone and Orchard Creek shale and their faunas in Illinois: Illinois Acad. Sci. Trans., vol. 10, pp. 261-275, 1917.

———. Stratigraphy and paleontology of the Alexandrian Series in Illinois and Missouri: Illinois Geol. Survey Bull. 23, pp. 67-160, 1917 (published in advance of bulletin in 1913).

formations recognized by him were named,[6] and a manuscript report on the quadrangle and an areal geologic map were prepared.[7] The mapping of the Mississippian formations in the Alto Pass quadrangle was begun in 1923 by Frank F. Krey and continued by George E. Ekblaw in 1924. Russell S. Poor assisted in this work both seasons. The Mississippian mapping has never been completed but a short report on the Mississippian strata was prepared by Poor as a master's thesis at the University of Illinois.[8] In 1923, Charles F. Bassett mapped the Devonian formations in the Alto Pass quadrangle under Savage's guidance, and submitted a report on this area as a master's thesis at the University of Illinois. This investigation resulted in the first recognition of true Oriskany strata in Illinois.[9]

This area in southern Illinois has proved to be one of the most difficult parts of the state to map geologically. Several conditions, none of them unique to this region, combine here to greatly obscure the geological relations. These are: (1) The presence of several comparatively thick formations not readily distinguishable by lithology, large parts of which are almost entirely nonfossiliferous; (2) unusually complete alteration of a large proportion of the exposed strata, principally by leaching and silicification, so that the original nature of the rocks is difficult to determine and correlations of altered and unaltered outcrops are uncertain; (3) exceedingly rough topography and a dense forest cover that in part account for numerous more or less important inaccuracies in the existing topographic maps and make the accurate location of geological observations at many places difficult or impossible; (4) thick and persistent residual chert, readily derived and constantly renewed from a succession of unusually siliceous formations, that greatly obscures or completely hides the bedrock on all but the steepest slopes and that chokes most of the smaller and steeper valleys; (5) loess deposits 30 or more feet thick mantling all of the hilltops and most of the more gentle

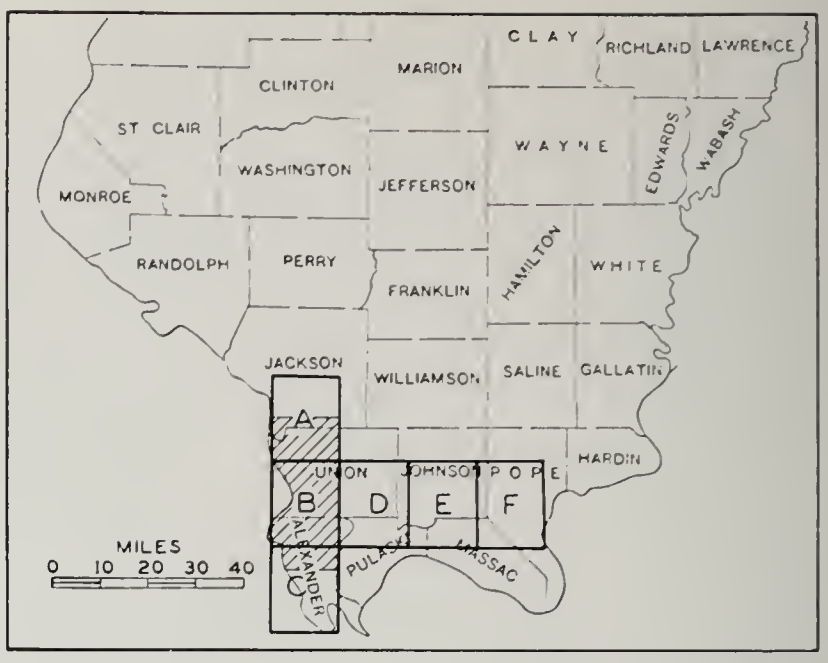

FIG. 1.—Index map of southern Illinois. Cross-hatching shows the area included on plate I. Quadrangles are: A, Alto Pass; B, Jonesboro; C, Thebes; D, Dongola; E, Vienna; and F, Brownfield. Maps of last three quadrangles accompany Report of Investigations No. 60.

slopes and from which large amounts of fine silt are washed into the valleys; (6) the occurrence of largely unconsolidated sands, gravels, and clays of Cretaceous and Tertiary age, particularly in the southern part of the area, which irregularly overlie the Paleozoic rocks and readily slump down into the valleys produced by more recent erosion; (7) water-laid silts of glacial age which fill all of the larger valleys to the level of the present drainage and stand at higher elevations as terrace remnants along the sides of the valleys so that outcrops are not abundant along many of the larger creeks where under other circumstances the best exposure might be expected to occur; (8) complicated structure involving folds of considerable magnitude and a great number of faults of different types and ages and variable intensity that are exceedingly difficult to locate and trace because of the general lack of readily recognizable stratigraphic horizons and the inadequacy of outcrops.

Various members of the Illinois Geological Survey and other geologists who have examined this area have felt that a restudy was advisable and this was undertaken by J. M. Weller early in 1940. He substantiated the general accuracy of the stratigraphic section as previously worked out but found it necessary to make extensive changes in the areal map of the pre-Mississippian formations. The map that accompanies this report (pl. I) is more than a revision of the older maps for it reflects a

[6]Savage, T. E., The Devonian formations of Illinois: Am. Jour. Sci., 4th ser., vol. 49, pp. 169-182, 1920.

[7]_____, Geology and mineral resources of the Jonesboro quadrangle: Illinois Geol. Survey, unpublished mss.

[8]Poor, R. S., The stratigraphy of the Mississippian system in the Alto Pass quadrangle: University of Illinois Master's thesis, unpublished mss.

[9]Bassett, C. F., The Devonian strata of the Alto Pass Quadrangle: Illinois Acad. Sci. Trans., vol. 18, pp. 360-368, 1925.

different viewpoint and different conclusions regarding several important stratigraphic problems. In addition, the northern portion of the Thebes quadrangle was mapped for the first time. In this latter part of the reconnaissance work, observations previously made by J. E. Lamar of the Illinois Survey and John R. Ball of Northwestern University were very helpful.

The geologic map of parts of the Alto Pass, Jonesboro, and Thebes quadrangles that is presented herewith is somewhat generalized because it was impracticable to reexamine all parts of the area in complete detail at this time. All important outcrops have, however, been restudied and all but the more inaccessible parts of the area have been more or less thoroughly traversed.

STRATIGRAPHIC SECTION

The outcropping strata present in the Alto Pass, Jonesboro, and Thebes quadrangles are classified as follows.

- Cenozoic
  - Pleistocene and Recent
    - Alluvium
    - Terrace deposits at various levels
    - Loess
  - Tertiary
    - Pliocene system
      - "Lafayette" gravel and sand
- Mesozoic
  - Cretaceous system
    - Gulf series
      - McNary sand and clay
- Paleozoic
  - Pennsylvanian system
    - Tradewater group
    - Cascyville group
  - Mississippian system
    - Chester series
      - Elvira group
        - Kinkaid limestone
        - Degonia sandstone
        - Clore limestone
        - Palestine sandstone
        - Menard limestone
        - Waltersburg sandstone
        - Vienna limestone
        - Tar Springs sandstone
      - Hombcrg group
        - Glen Dean limestone
        - Hardinsburg sandstone
        - Golconda limestone
        - Cypress sandstone
      - New Design group
        - Paint Creek formation
        - Renault formation
    - Iowa series
      - Meramec group
        - Ste. Genevieve formation
          - Hoffner beds
          - Ste. Genevieve limestone
    - *Mississippian system—Continued*
      - St. Louis limestone
      - Warsaw-Salem limestone — Lower Mississippian
      - Osage group — Lower Mississippian
      - Burlington-Keokuk limestone — Lower Mississippian limestone
      - Hartline chert
      - Kinderhook group
        - Springville shale
- Devonian system
  - Upper Devonian series
    - Chautauquan group
      - Mountain Glen shale
    - Senecan group
      - Alto limestone
  - Middle Devonian series
    - Erian group
      - Lingle limestone
      - (Misenheimer shale)
    - Ulsterian group
      - Grand Tower limestone
      - Dutch Creek sandstone
      - Clear Creek chert
  - Lower Devonian series
    - Oriskanian group
      - Backbone limestone
      - Grassy Knob chert
    - Helderbergian group
      - Bailey limestone
- Silurian system
  - Niagaran series
    - Bainbridge limestone
  - Alexanderian series
    - Sexton Creek limestone
    - Edgewood limestone
    - Girardeau limestone
    - Orchard Creek shale
- Ordovician system
  - Cincinnatian series
    - Thebes sandstone
    - Fernvale limestone
  - Mohawkian series
    - Kimmswick limestone

Ordovician System

Only the uppermost part of the thick Ordovician section present in the Ozark region crops out in southern Illinois and its exposures are confined to a narrow zone in and near the bluffs of Mississippi River in the vicinity of Thebes and to a few other small areas farther north where these beds have been brought to the surface at the crest of an anticline.

Kimmswick limestone.—The Kimmswick limestone is the oldest formation exposed in southern Illinois. It consists entirely of massively bedded comparatively pure limestone. Coarsely crystalline massive white strata having the appearance of marble occur in the lower part of the formation and are exposed in a cut on the Chicago and Eastern Illinois Railroad a short distance south of Thebes in the SE. ¼ sec. 17, T. 15 S., R. 3

W. Higher beds are finer-grained and are predominantly gray to brownish dense limestone with more or less abundant scattered calcite crystals. Some dark colored chert is present but is not abundant. This part of the formation crops out at several places along the road south of Thebes in the SE. ¼ sec. 17 and may be observed to advantage nearby in the east bank of the Mississippi south of the railroad bridge during low water stages. In addition to the area south of Thebes the Kimmswick limestone is reported to crop out a fourth of a mile north of Thebes and on Little Rock Island southwest of Gale, but the outcrops have not been observed recently at either of these places. South of Thebes, Kimmswick outcrops rise to a height of about 100 feet above the river and this probably represents nearly the complete thickness of the formation.

Fernvale formation.—The Fernvale limestone is a persistent thin formation that overlies the Kimmswick everywhere in the Mississippi Valley except where it has been removed by erosion. It is dark gray to brownish coarsely crystalline limestone with abundant fossils, and Savage records thicknesses of 3½ and 1½ feet south and north of Thebes respectively. It may be observed to better advantage, however, west of Mississippi River at North Main Street and Broadway in the city of Cape Girardeau where the formation is 8 feet thick.

Thebes sandstone.—This formation is characteristically developed at Thebes, from which town it was named, and it crops out intermittently in and near the Mississippi River bluffs from one mile north of Gale to three miles south of Thebes. It is a very fine-grained compact sandstone deposited in even beds and appears quite massive in fresh exposures but weathers into shaly layers. It is bluish-gray where fresh, but weathers to yellowish-brown at almost all exposures. The fresh sandstone, preserving in part its original gray color and even bedding, is best exhibited in a cut on Illinois State Highway No. 3 just southeast of Gale in the NW.¼ sec. 4, T. 15 S., R. 3 E. Its shaly weathered appearance is well shown in the bank of Mississippi River where extensive exposures may be seen at low water north of Thebes in sec. 5 and south of Thebes in the NW. ¼ sec. 28 of the same township. The Thebes sandstone attains a thickness of a least 75 and probably 100 or more feet.

Commonly the Thebes sandstone directly overlies the Fernvale limestone or locally the Kimmswick limestone. At some places, however, as much as 12 feet of shale comparable to part of the overlying Orchard Creek intervenes between these formations, as for example at North Main Street and Broadway in Cape Girardeau. Northward in Missouri the Thebes sandstone thins consistently and fairly rapidly. In Ste. Genevieve County, Missouri, it has a maximum thickness of 20 feet and near Valmeyer in Monroe County, Illinois, it is absent. These facts suggest that the Thebes sandstone is a local lenticular member in the lower part of a succession of shaly beds that to the north are referred to the Maquoketa formation. The lower Maquoketa age of the Thebes sandstone is substantiated by the occurrence of fossils in both Alexander County, Illinois, and Ste. Genevieve County, Missouri, similar to those occurring near the base of the more typical Maquoketa farther north where the Thebes member is not developed.

Silurian System

The Silurian is the least well represented Paleozoic system in southern Illinois. As commonly delimited in this part of the State it consists of five comparatively thin formations whose aggregate thickness probably does not exceed 200 feet.

The proper horizon at which to separate the Ordovician and Silurian systems is somewhat doubtful. Savage has consistently included the Girardeau limestone, which carries a fauna of mixed Ordovician and Silurian affinities, in his Alexandrian series at the base of the Silurian system because of the common assumption that the appearance of new forms of life is more significant than the continuance of old forms. Originally he referred Orchard Creek shale to the Richmond series, conceded by most geologists to be upper Ordovician, but the similarity of fossils in these two formations and the absence of a stratigraphic break between them caused him later to transfer the Orchard Creek shale to the Silurian. There is little doubt, however, that the Orchard Creek shale is the southward continuation of part of the Maquoketa formation (of Richmond age). Also there is no doubt that the Girardeau limestone is more closely related to the Orchard Creek shale, into which it im-

perceptibly grades, than it is to the overlying Edgewood and Sexton Creek limestones from which it is everywhere separated by a pronounced unconformity. Therefore, it would appear more logical to recognize the post-Girardeau unconformity as the systemic boundary and class the Girardeau fauna as of very late Ordovician age rather than very early Silurian age.

Orchard Creek Shale.—The Orchard Creek consists of greenish-gray to drab silty and slightly calcareous shale with a maximum observed thickness of 22 feet. The middle and upper parts of the formation include abundant layers of limestone up to 2 inches thick that are mainly earthy and impure but toward the top they resemble more and more the overlying Girardeau limestone into which the formation grades. The contact of the Orchard Creek shale with the Thebes sandstone is sharp, showing an abrupt change in the type of sediment deposited in this area, but there is no evidence of unconformity representing emergence and erosion.

Because of its shaliness the Orchard Creek formation is rarely well exposed, and localities cited by Savage as good outcrops are now slumped over and covered with vegetation. An 18-foot slope underlain by this formation occurs beside State Highway No. 3 southeast of Gale in the northern part of sec. 4, T. 15 S., R. 3 W., and fragments of the limestone layers strew the bank of the Mississippi River at low water in sec. 5 between Gale and Thebes. The best exposures of this formation now occur in the south bank of Salamans Creek in the east-central part of sec. 10, and well laminated greenish shale without limestone bands that may be part of the Orchard Creek crops out beneath the trestle of the Missouri Pacific Railroad on the south side of Powder Mill Hollow near the southeast corner of sec. 28, all in the same township.

Girardeau limestone.—The Girardeau limestone consists of discontinuous undulatory lenticular layers 2 to 4 inches thick separated by shale partings. The limestone is mostly dark gray, brittle, lithographic, and nonfossiliferous, but some layers are slightly crystalline and contain a few fossils. The shale partings are drab, calcareous, and some of them are very fossiliferous. They are most conspicuous in the lower part of the formation and there appears to be perfect gradation from the Orchard Creek shale below into the Girardeau limestone above. In the upper part of the Girardeau formation the shale partings are much thinner and are not conspicuous on fresh exposures, but this part of the formation weathers to lenticular beds like that below. A moderate amount of nodular black chert is irregularly distributed throughout the upper part of the formation.

An important unconformity separates the Girardeau limestone from the overlying Edgwood or Sexton Creek limestones, and because of a variable amount of erosion the thickness of the Girardeau is quite inconstant. The best exposure of this formation occurs at the cascades of Orchard Creek south of Thebes near the center of the W. ½ sec. 21, T. 15 S., R. 3 W., and other good outcrops are present in the south bank of Harrison Creek near the middle of sec. 16, T. 13 S., R. 2 W. About 30 feet of limestone is shown at each of these places and the total maximum thickness of the formation is probably slightly greater. Smaller outcrops of the Girardeau limestone occur at intervals in road and railroad cuts both north and south of Thebes, but the thickness of the formation at these places cannot be determined. Savage reports an outcrop of this limestone in a branch of Ubedam Creek in sec. 28, T. 13 S., R. 2 W. This is no longer visible but a few loose fragments of Girardeau limestone are present in the creek bed. In the SE. ¼ sec. 5, T. 15 S., R. 3 W., this formation was largely removed by erosion and in the bank of Mississippi River the Edgewood limestone overlies no more than 2 or 3 feet of limestone that may be assigned to the Girardeau. This formation is entirely absent in the road-cut beside State Highway No. 3 southeast of Gale where the Edgewood directly succeeds Orchard Creek shale.

Edgewood formation.—The Edgewood formation is a very thin and discontinuous limestone of variable lithology that appears to have been deposited in depressions eroded in the Girardeau limestone. It has been observed in only a small area in southern Illinois north and northeast of Thebes and its distribution elsewhere in this part of the State is unknown. In the road-cut on State Highway No. 3 southeast of Gale this formation is 1½ feet thick and overlies Orchard Creek shale. Here it is a hard stratum

consisting partly of dark gray richly oolitic limestone and partly of conglomeratic limestone containing pebbles apparently derived from the erosion of the nearby Girardeau limestone. A thicker development of the Edgewood may be observed at low water in the bank of Mississippi River in the SE. ¼ sec. 5, T. 15 S., R. 3 W. Here its most prominent part is a 3- to 4-foot bed of massive dark gray crystalline limestone that is oolitic in the upper part and contains many fossils, particularly gastropods, which are filled with white crystalline calcite. Beneath this is about 8 feet of more thinly bedded strata consisting of fine-grained to earthy limestone, a small amount of chert, calcareous to silty shale some of which is sun-cracked, limestone conglomerate containing some fairly large pieces of Girardeau limestone, and a thin layer or two of coarse more or less hematitic oolite. At this place 2 or 3 feet of Girardeau limestone intervenes between the Orchard Creek and Edgewood. Other outcrops occur along Salamans Creek in the E. ½ sec. 10 of the same township.

Sexton Creek limestone.—The Sexton Creek limestone in southern Illinois has been observed to overlie both the Edgewood and Girardeau limestones and may overlap locally upon the Orchard Creek shale. In the neighboring part of Missouri it is reported to overlap upon strata as old as the Kimmswick limestone. The Sexton Creek consists exclusively of more or less cherty limestone and may locally attain a thickness of about 40 feet although elsewhere it is doubtless much thinner. The lower part of the formation is composed of gray more or less crystalline limestone with abundant thin tabular masses or continuous beds of chert. Higher strata are more massive, crystalline, generally darker colored, and slightly glauconitic and include much less chert. Above beds of this type occurs limestone with conspicuous pink grains that has been assigned by some geologists to the Sexton Creek and by others to the Bainbridge. In this report it is considered to be the basal member of the Bainbridge formation.

The type outcrops of the Sexton Creek limestone occur in the Mississippi River bluff in sec. 27, T. 14 S., R. 3 W., but this locality is not easily accessible nor is the limestone as favorably exposed as it once was. The best outcrop is now located at the point of the river bluffs just north of the mouth of Dongola Hollow in the NW. ¼ sec. 12 in the same township. Here the Sexton Creek underlies the Bainbridge limestone and both parts of the formation described above are well exposed. The outcrops at this place are cut by two small faults with throws of about 20 feet and 8 feet respectively. Much more limited outcrops of the Sexton Creek limestone occur in the bluff both north and south of Thebes, along the lower course of Orchard Creek, beside State Highway No. 3 at the road-cut southeast of Gale, in a branch of Ubedam Hollow, and along the north tributary of Harrison Creek in the northern part of sec. 16, T. 13 S., R. 2 W.

Bainbridge limestone.—The Bainbridge limestone is probably the most unique and easily recognized formation in Illinois. Its earthy brick-red limestone, more or less mottled with green, is equally characteristic of outcrops and subsurface records. The basal member of the formation as here identified consists of rather massive limestone, partly crystalline and partly dense, gray, brownish, or reddish and containing more or less abundant reddish or pink calcite crystals or fossil fragments. These beds are well exposed in the Mississippi bluff just north of the mouth of Dongola hollow and also crop out on the south side of Ubedam Hollow on the south line of sec. 20, T. 13 S., R. 2 W. This member attains a thickness of 10 to 20 feet. It is overlain by the typical Bainbridge limestone consisting of earthy impure and locally shaly beds of a dominant dull to bright red color, mottled or irregularly streaked with gray or greenish-gray. These strata become more shaly upward and grade into red, greenish, and drab calcareous shale which is rarely exposed. The most accessible outcrops of the earthy red mottled limestone occur along Orchard Creek near the center of the north line of sec. 27, T. 15 S., R. 3 W., and along a branch of Salamans Creek in the SE. ¼ SW. ¼ sec. 2 of the same township. An exceptionally good outcrop is present in the upper part of a small forked hollow in the SW. ¼ NE. ¼ SE. ¼ sec. 28 of the same township. Other smaller exposures occur along the road and upper railway south of Thebes in sections 21 and 28, in the bluff north of Dongola Hollow near the center of the west line of sec. 12, T. 14 S., R. 2 W.,

in a branch of Ubedam Hollow near center north line sec. 28, T. 13 S., R. 2 W., and in the north branch of Harrison Creek near the center north line NE. ¼ sec. 9 of the same township.

The contact of the Bainbridge and overlying Bailey limestone has nowhere been observed, and the thickness of the Bainbridge cannot be accurately estimated. About 40 feet of this formation is exposed in the small hollow south of Thebes in sec. 28 mentioned above. In the bluff north of the mouth of Dongola Hollow the lowest exposed Bailey limestone occurs 130 feet above the top of the Sexton Creek, but some and perhaps a considerable part of the 105-foot covered interval here is undoubtedly underlain by shaly strata that belong to the lower part of the Bailey formation.

Devonian System

The thickest outcropping section of the Devonian system in Illinois occurs in the area adjacent to the Mississippi River in southern Jackson, western Union, and northern Alexander counties. It is here somewhere in the neighborhood of 1500 feet thick, but the details of this succession are difficult to determine because of the deep weathering and alteration of the formations, the probable existence of important unconformities, considerable lateral variation, and the existence of numerous structural irregularities. The greater part of the Devonian system as it is exposed at the surface consists of a monotonous succession of novaculitic chert.

Bailey limestone.—The Bailey limestone is a thin-bedded very earthy and siliceous formation that contains much chert. The limestone is medium gray, dense or slightly shaly, and mostly occurs in beds less than 4 inches thick. It weathers to buff or gray, and much of it is so impure that when it is completely leached of its lime content the strata are not reduced in thickness. Chert is present in irregularly rounded nodules or thin more or less continuous sheets that at many places have no sharp outer boundaries and seem to grade into the surrounding limestone. In southern Jackson and northern Union counties the chert is mostly gray but towards the south its color becomes darker and it is locally almost black. It commonly weathers to light olive drab or gray colors. Parts of the Bailey limestone may become quite shaly upon weathering, and calcareous or dolomitic shaly beds, commonly greenish, are present in the lower part of the formation.

Unweathered Bailey limestone is well exposed in the Mississippi River bluffs at many places, particularly in T. 11 S., R. 3 W., where sheer cliffs rise to a height of more than 100 feet, but there is no place where the complete thickness of the formation can be accurately estimated. It is certainly more than 200 and may be as much as 350 feet thick as suggested by the record of the Barsinger well recently drilled near Grand Tower. The contact with the Bainbridge limestone has not been observed and these two formations may be transitional. Local development of red color similar to that in part of the Bainbridge formation occurs in the lower part of the Bailey in the SW. ¼ SW. ¼ sec. 12, T. 15 S., R. 3 W., and in the NW. ¼ SW. ¼ sec. 19, T. 15 S., R. 2 W., and shale similar to some of that present in the upper part of the Bainbridge may be seen grading upward into impure cherty Bailey limestone in the south bank of Horse Creek in the SW. ¼ sec. 23, T. 14 S., R. 3 W.

A fine exposure of weathered Bailey limestone may be studied in a deep cut along State Highway No. 3 in the S. ½ sec. 15, two miles southeast of Thebes. Here the stratification continues evenly from knobs of unweathered limestone into the weathered portion of the formation, and it is evident that weathering has produced a notable increase in chert content. Here and elsewhere continuous chert layers up to 6 inches or more thick make up much of the weathered formation; in the unweathered limestone, chert beds of comparable magnitude occur only in the upper part of the formation.

The transition of the Bailey limestone into the overlying Grassy Knob chert is well shown in the bluff above Big Muddy River in the SW. ¼ sec. 27, T. 10 S., R. 3 W., in southern Jackson County.

Grassy Knob chert.—The Grassy Knob constitutes the lower part of the light gray to white novaculitic chert succession that is the most prominent part of the Devonian system in southwestern Illinois. It is 185 feet thick in the Barsinger well near Grand Tower. In the bluffs above Big Muddy River in the SW. ¼ sec. 27, T. 10 S., R. 3

W., the transition from the Bailey to Grassy Knob is well exposed. Bedded chert becomes more prominent and the interbedded layers of impure limestone become thinner. The chert gradually grades from the gray color characteristic of the Bailey in this area to white with irregular fine mottling of gray or brown. As the chert becomes more massive, stylolitic partings appear. Here the lower third of the Grassy Knob is composed principally of chert in beds up to a foot or more thick. The middle third is extremely massive chert, partly a firmly cemented breccia, with some stylolitic partings but little indication of bedding. The upper third is mainly concealed by talus but probably consists of alternating layers of chert and dolomitic limestone. Fossils are scarce throughout the entire formation.

The Grassy Knob and Clear Creek cherts are so similar that they are difficult to differentiate except where the intervening Backbone limestone or its cherty equivalent can be identified. The most characteristic part of the Grassy Knob is its extremely massive middle portion. This forms a prominent bluff consisting of 80 feet of solid chert in the NW. corner of sec. 32, T. 13 S., R. 2 W. and in the neighboring parts of adjoining sections. At most places it is considerably shattered, however, and crops out less conspicuously. Large blocks tumble down the hillsides and sharp fragments of white chert fill the beds of ravines. It is believed to underlie Atwood Ridge in the E. ½ sec. 33, T. 12 S., R. 2 W., Vick Hill in the SW. ¼ sec. 8 and Bass Hill in the NW. ¼ sec. 10, both in T. 14 S., R. 12 W. Similar material is well exposed in a tributary to Ambeer Branch in the NW. ¼ sec. 5, T. 15 S., R. 2 W., and in the neighboring part of sec. 32 to the north, as well as at many other places.

In Alexander County the basal part of the Grassy Knob is less cherty than it is in southern Jackson County. More or less well bedded siliceous clay, probably produced by the leaching of impure limestone, makes up a progressively greater proportion of the lower strata as they are traced southward. This part of the section is exposed by the roadside in the upper part of Dongola Hollow in the SW. ¼ SE. ¼ sec. 7, T. 14 S., R. 2 W., in the valley of Wolf Creek near the center E. ½ sec. 18, T. 15 S., R. 2 W., and at the Olive Branch silica mine near the SE. corner of sec. 29 of the same township. At the last two localities the exposed beds are probably close to the top of the Bailey limestone.

The Grassy Knob chert is probably succeeded unconformably by the Backbone limestone. This contact is exposed in the bluff above Big Muddy River in the SW. ¼ sec. 27, T. 10 S., R. 3 W. and in the south bank of a large tributary to Hutchins Creek in the SW. ¼ sec. 23, T. 11 S., R. 2 W. At both of these places the contact is sharp, and massive crystalline fossiliferous Backbone limestone slightly overhangs fine-grained impure limestone, probably dolomitic, with nodules and beds of chert. In southern Union County and in Alexander County, no outcrops of the Backbone formation have been recognized and it has consequently not been mapped. In this area the upper limit of the Grassy Knob chert is quite uncertain and as mapped may include strata of Backbone age that are probably present, at least locally.

Novaculite is a name used in this country for a peculiar type of chert, best known in Arkansas, consisting of finely crystallized silica. It is more or less calcareous where unweathered and is used for the manufacture of fine whetstones. The Devonian chert of southern Illinois resembles the Arkansas novaculite in many respects. Where unshattered it breaks with a subconchoidal fracture and possesses surfaces with little or no vitreous luster. It is generally very light gray to white in color but appears more or less reddish in outcrop because of ferruginous staining of the fracture surfaces. Where fresh it is commonly mottled with abundant small irregular areas of darker gray or brown. These areas are more calcareous than the surrounding lighter colored chert and upon prolonged weathering they may be leached out leaving the chert in a porous "worm-eaten" condition.

The Grassy Knob formation at one time obviously contained much calcium carbonate. It probably was originally a more or less siliceous limestone with scattered beds and nodules of chert. In some way that is not thoroughly understood, it was later altered. The silica which it originally contained was apparently concentrated, replacing certain layers of limestone. Probably much additional silica was added to the formation from some outside but unknown

source. The fact that novaculitic chert is most prominently present in Arkansas, southern Illinois, and western Tennessee in a zone concentric with Cretaceous deposits of the upper Mississippi embayment, suggests that the Cretaceous sea may have played an important role in the development of novaculite but if so, the original nature of the Devonian limestones was probably an equally important factor inasmuch as other limestones, presumably of somewhat different character, were not similarly altered or silicified to the same degree.

The stylolites of the Grassy Knob chert, not uncommonly possessing fluted columns an inch or more in length, are almost certainly relic structures developed by the differential solution of the limestone before its alteration. Some limestone beds of the formation were leached away rather than silicified, and the impurities which they contained remain as layers of light gray to slightly greenish gritty plastic clay now separating beds of chert. The alteration of the formation probably resulted in a considerable decrease in its thickness, and the consequent settling of the strata that remained caused the fracturing and shattering that is so characteristic of the chert. Such readjustment was also responsible for the locally abundant slickensides developed in some of the more massive chert beds.

Backbone limestone. — The Backbone limestone is better exposed in the bluff above Big Muddy River in the SW. ¼ sec. 27, T. 10 S., R. 3 W. than it is at the southern end of the Backbone Ridge north of Grand Tower, both in Jackson County. Its most extensive outcrops, however, occur in Union County along Hutchins Creek from sec. 1 to sec. 25, T. 11 S., R. 3 W., and in the banks and hills above a tributary to that stream in secs. 14 and 23 of the same township. At all these places it consists of light gray massive crystalline limestone that becomes increasingly cherty to the southeast. Some portions of this limestone are very fossiliferous and much of it is crinoidal. It commonly weathers to a rough surface upon which crinoid stem segments, some of large size, are conspicuous.

No chert has been observed in this formation at the Backbone Ridge. In the bluff above Big Muddy some chert is present in the 100 feet of limestone which makes up the lower part of the formation but it is neither abundant nor conspicuous. Along Hutchins Creek, and particularly above its tributary in sec. 23, some 30 feet of massive chert-free limestone occurs at the base of the formation which grades upward into somewhat finer-grained probably more siliceous limestone in which more or less irregular beds of chert are present. As the chert becomes more abundant the Backbone limestone loses much of its massive appearance. Much of the chert is highly crinoidal and where weathered contains abundant casts of crinoid stem segments. Bryozoans are likewise present, but other types of fossils are comparatively scarce. In these respects the Backbone chert differs and can be distinguished from the cherts of the overlying and underlying formations.

There is no place where the thickness of the Backbone limestone can be accurately estimated. In the Barsinger well near Grand Tower 150 feet of this formation occurs immediately beneath the alluvium, and in this area of southern Jackson and northern Union counties it may attain a thickness of 200 feet or more. To the south, however, it is probable that the formation is much thinner and locally it may be absent. The Backbone limestone succeeds the Grassy Knob chert unconformably, as noted in the description of that formation. It is likewise overlain unconformably by the Clear Creek chert. This contact has been observed only in the W. P. A. quarry near the south end of the Backbone Ridge where it is sharp and undulatory.

Unweathered Backbone limestone crops out only at the places mentioned above and in a small area along Clear Creek in the NE. ¼ SE. ¼ sec. 29, T. 11 S., R. 2 W., and the presence of weathered Backbone limestone elsewhere is more or less uncertain. Crinoidal and bryozoan-bearing chert characteristic of this formation has been observed in place along the new Forest Service road at or near the NE. corner of sec. 9, T. 11 S., R. 3 W., and in the bank of Silica Hollow in the SW. ¼ SE. ¼ sec. 35 of the same township. It doubtless is continuous between these places. Farther south, however, no outcrops of this formation have been recognized and it has not been mapped, but it must be present at least locally because fragments or blocks of crinoidal bryozoan bearing chert were found in the NW. ¼ NE. ¼ sec. 33, T. 12 S., R. 2 W. and

near the center sec. 3, T. 14 S., R. 2 W. Blocks of bluish-gray porous chalcedonic chert with fossils similar to those in the lower part of the Backbone limestone occur in the quarry of the Novaculite Paving Company at Tatumville, but the thin stratum from which they have been derived was not located in the quarry face. Nevertheless they are evidence that the Backbone limestone is probably present, although perhaps very thin, at that place.

Clear Creek chert.—The Clear Creek chert is the most extensively exposed and probably the thickest of the Devonian formations in southern Illinois. It consists principally of novaculitic chert, although fine-grained very siliceous limestone in variable amounts is present at many outcrops in northern Union County. Much of the chert, particularly in northern Union County, is white, somewhat calcareous, and has the appearance of unglazed porcelain. This type of chert, where unweathered, encloses subordinate amounts of fine-grained siliceous limestone in thin discontinuous beds, nodule-like masses, and slender cylindrical strands which penetrate the chert in all directions. Where the limestone has been removed by leaching, the chert has been left as an exceedingly rough, porous, vesicular mass. This type of chert is well exposed in the bank of Hutchins Creek in the SE. ¼ sec. 1, T. 11 S., R. 3 W. and along Darty Creek in the north part of sec. 15, T. 12 S., R. 2 W., where at places it spalls off in thin irregular slabs parallel to the surface of exposure. The porcellaneous chert is probably largely of secondary origin, and well developed stylolitic seams cut the chert, locally separate chert from siliceous limestone, and at a few places have been observed to pass completely from chert to limestone. The silica deposits worked extensively west of Elco and elsewhere in the vicinity are believed to have been largely produced by the weathering and leaching of this type of chert.

There are all gradations between the type of chert described above and the denser, less calcareous, more or less well bedded chert characteristic of the Grassy Knob formation which appears to be most extensively developed in the Clear Creek formation in its lower part and in the southern area of its exposure. Outcrops of these two formations are in general so similar that it is exceedingly difficult to differentiate them. The Clear Creek, however, is much more fossiliferous, particularly in its upper part, than is the Grassy Knob, and some beds are literally crowded with specimens. They are preserved almost exclusively as molds and casts, and excellent specimens may be obtained from some of the harder weathered chert layers. Very massive chert, such as constitutes the middle part of the Grassy Knob formation, is not abundant in the Clear Creek whose beds are generally distinct and not more than one foot thick. Some massive chert, however, is locally present in the Clear Creek and gives rise to larger boulders on the slopes and in the ravines of Bald Knob southwest of Alto Pass and elsewhere.

There is no place where the thickness of the Clear Creek formation can be measured. It cannot be less than 300 feet thick and may attain a maximum considerably in excess of this figure. Bald Knob, which rises 600 feet above the valley of Clear Creek, is composed of Clear Creek chert from top to bottom but this is probably not a measure of the formation because the hill is believed to mark a structural high.

Limestone in the Clear Creek formation is exposed only in the area north of State Highway 146 which extends west from Jonesboro. Limestone in the other Devonian formations above the Bailey is likewise confined, with few exceptions, to this same area. Either there was important and fairly rapid north to south lateral gradation in the type of rock that originally made up these formations or else silicification and subsequent weathering has progressed to lower elevations in the southern than in the northern part of this area. Although both explanations may be applicable, the latter appears to be the more important. The hills and ridges of the pre-Mississippian area rise in altitude to the north, and their topography suggests that they are parts of a warped and now deeply dissected peneplain, probably of post-Eocene age. Near Fayville the highest hills rise to nearly 600 feet and are underlain by Cretaceous deposits. Near Delta this surface is represented by flat-topped hills at about 700 feet. It continues to rise to the north, and near the north line of Union County probably stands at an elevaiton of about 850 feet. Beneath these elevations at various places small remnants of

the Cretaceous deposits are still preserved, and spread out upon this surface were late Tertiary gravels. Rising above this peneplain are such elevations as Bald Knob and Atwood Ridge, which are capped by massive chert, and the Tertiary gravel is not known to be present upon their summits.

It seems probable that the depth of leaching of the Devonian limestones was related to this peneplain surface. Differences in elevation between the projected peneplain and limestone outcrops suggest that leaching was effective to a depth of nearly 400 feet.

The Clear Creek chert unconformably overlies the Backbone limestone. Its contact with the overlying Dutch Creek sandstone has been observed in the bank of Clear Creek near the west line of sec. 27, T. 11 S., R. 2 W. At this place the upper part of the Clear Creek formation consists of gray fine-grained siliceous limestone with subordinate chert. It is directly overlain by sandstone with no suggestion of transitional beds, and an unconformity may also occur at this horizon.

Dutch Creek sandstone.—The Dutch Creek sandstone is a comparatively thin and highly characteristic formation. It is the only restricted zone in the Devonian succession of southwestern Illinois that can be invariably recognized, but actual outcrops of this formation in place are not abundant. Residual boulders, however, are widespread, and their number and size give some hint as to the nearness of the place from which they were derived.

The Dutch Creek is a massive sandstone composed almost exclusively of rounded grains of the St. Peter type, doubtless derived from the erosion of older strata in the Ozark region of Missouri. The sandstone is commonly white or lightly ironstained and friable, but its weathered surfaces are case-hardened and stained dark brown by limonite. Boulders derived from this formation are resistant, but once the outer surface is broken the interior generally crumbles readily. For this reason residuum from the Dutch Creek persists upon many hill tops and slopes west of its present outcrop but disintegrates rapidly along the stream courses where it is mingled with abundant sharp chert fragments; consequently the sandstone boulders are not commonly transported by the streams far from their place of origin. Locally the Dutch Creek sandstone is more or less quartzitic and may be brecciated and more or less heavily impregnated with limonite, these alterations probably having been accomplished by agencies accompanying local structural disturbances and deformation. The formation is almost everywhere fossiliferous and probably originally was very calcareous. The fossils, many of them large and conspicuous, are preserved as casts and molds, and the surfaces of the sandstone are commonly coarsely pitted as the result of weathering and enlargement of the fossil cavities.

Good outcrops of the Dutch Creek sandstone occur in the northeast bank of Clear Creek near the west line of sec. 27, T. 11 S., R. 2 W., in the bank of Darty Creek in the SW. ¼ SE. ¼ sec. 10, T. 12 S., R. 2 W., beside the road in the SE. ¼ NW. ¼ sec. 26 of the same township, near the head of South Ripple Hollow at the center of sec. 8, T. 14 S., R. 2 W., by the roadside south of Delta in the SW. ¼ NW. ¼ sec. 21 of the same township, and by the roadside south of Elco in the SW. ¼ NW. ¼ sec. 19, T. 14 S., R. 1 W. At only the first of these places can the thickness of the formation be estimated and here it cannot be much more than 10 feet. Elsewhere it is probably thicker but it is unlikely that its thickness anywhere exceeds 30 feet.

The Dutch Creek sandstone probably overlies the Clear Creek chert with slight unconformity. It grades upward into the Grand Tower limestone through a few inches or feet of calcareous sandstone and sandy limestone. This transition is best exposed at the point of the hill south of Dutch Creek in the NE. ¼ sec. 19, T. 12 S., R. 2 W. and was also observed in the south bank of Clear Creek in the SE. ¼, SW. ¼ sec. 27, T. 11 S., R. 2 W. The Dutch Creek sandstone is not exposed near Grand Tower, but at the Bakeoven north of the Backbone Ridge the lowest strata of the Grand Tower limestone observable at low water are filled with rounded sand grains of the St. Peter type.

Sandstone very similar to the Dutch Creek and composed almost exclusively of similar rounded grains but without the impressions of fossils occurs in the Cretaceous deposits. Such sandstone may be seen in a cut of the Missouri Pacific Railroad in the

NW. ¼, SE. ¼ sec. 28, T. 15 S., R. 3 W., and boulders of similar sandstone occur on the hillside in the NW. ¼ sec. 29, T. 12 S., R. 2 W. where the Dutch Creek is below drainage. Massive sandstone believed to be of similar age is present along the hillside southeast of the road near the center of sec. 11, T. 13 S., R 2 W., at a higher elevation than outcrops of the "Misenheimer" shale.

Grand Tower limestone.—The Grand Tower limestone is best exposed at the Devil's Bakeoven north of Grand Tower[10] where nearly the entire thickness of the formation, 124 feet as measured by Savage, may be observed. It appears to thin southward and is not known south of the latitude of Jonesboro. This formation consists of light to dark gray, generally granular to finely crystalline, more or less thick-bedded limestone. Most of it is quite pure although the lower beds are very sandy and some of the higher strata are argillaceous and slightly shaly. The lightest colored beds occur in the lower part of the formation, and the little chert which is present is confined to the uppermost strata. It is fossiliferous throughout although specimens are not especially common except in a few restricted layers. The Grand Tower limestone in northern Union County is similar in character, but outcrops are restricted and the formation appears to thin out to the southward and is not known to extend much south of Highway 146. Good exposures occur, however, in the SW. ¼ NW. ¼ sec. 1, T. 11 S., R. 3 W., near the middle of the south line of sec. 27, T. 11 S., R. 2 W., and along the hillside in the E. ¼ sec. 9, T. 12 S., R. 2 W. Sink-holes mark the outcrop of this formation, as at the first locality mentioned above and along the road through the center of sec. 10, T. 12 S., R. 2 W.

The Grand Tower limestone succeeds the Dutch Creek sandstone conformably but appears to be separated by an unconformity from the overlying Lingle limestone. This contact has been observed only in the hills north of Grand Tower where an abrupt change in lithology and fossils occurs.

"Misenheimer" shale and "Lingle" and "Alto" limestones.—The strata intervening between the Grand Tower limestone (or the Dutch Creek sandstone where that is absent) and the black Mountain Glen shale (or the Springville shale where that is absent) have been referred by Savage to the Misenheimer shale and the Lingle and Alto limestones.[11] Restudy of this area, however, suggests that the recognition of these three formations may be neither stratigraphically logical nor practically feasible. Along the eastern border of the Devonian area where these strata rise to the surface, outcrops are mostly small and discontinuous. There are no sections where the relations of these proposed formations can be precisely determined, and many minor structural irregularities occur. As a result little can be determined as to the details of this part of the stratigraphic section and it might be advisable to apply to them the name St. Laurent formation which is used for the Devonian beds overlying the Grand Tower limestone in southeastern Missouri.[12]

Limestone referred to the Lingle apparently overlies the Grand Tower unconformably in the Devil's Backbone and Bakeoven. It is mainly dark colored, more or less impure with some shaly layers, and certain strata are crowded with fossils. In northern Union County outcrops occur in the NE. ¼ NE. ¼ sec. 2, T. 11 S., R. 3 W., near the center of the E. line of the SW. ¼ sec. 21, T. 11 S., R. 2 W. and near the center of the N. line NE. ¼ sec. 34 of the same township. At the last place a section at least 50 feet thick was measured by Savage some years ago when the beds appear to have been more favorably exposed than they are now. Here chert is present in certain layers and some dark colored oolitic limestone occurs. Some of the beds are exceedingly fossiliferous. To the south this part of the sequence grows shaly. Limestone of the Lingle type associated with shaly and silty strata occurs in several small outcrops in the south bank of Darty Creek in the SE. ¼ sec. 10, T. 12 S., R. 2 W., and similar strata formerly cropped out along Green Creek in the north part of sec. 23 of the same township before State Highway 146 was constructed. Limestone referable to the Lingle is also exposed near the middle of the E. ½ sec. 19 and near the NW. corner of sec. 29, T. 12 S., R. 2 W. South of Jonesboro limestone of

[10]Tower Rock near the Missouri side of the Mississippi River from which the town of Grand Tower was named consists of Bailey limestone.

[11]Savage, T. E., The Devonian formations of Illinois: Am. Jour. Sci., 4th ser., vol. 49, pp. 176-177, 1920.

[12]Weller, Stuart, and St. Clair, Stuart, Geology of Ste. Genevieve County: Mo. Bur. Geol. and Mines, ser. 2, vol. 22, 1929.

the Lingle type is known only near the headwaters of Lingle Creek in the southwest part of sec. 26 and along Misenheimer Creek in the west part of sec. 35, both in T. 13 S., R. 2 W. At these places boulders of hard dark gray finely crystalline crinoidal chert-bearing limestone have tumbled out of the hillsides from above silty shale that has been referred to the Misenheimer.

On Darty Creek in the SW. ¼ sec. 10 and at the spillway of the State Pond in the S. ½ of sec. 14, T. 12 S., R. 2 W., the black Mountain Glen shale overlies very dark colored and siliceous chert-bearing limestone with few fossils which Savage referred to the Alto formation. The thickness of these strata and their relations to the underlying Lingle limestone are not known. The contact with the overlying black shale, however, is sharp and doubtless unconformable. Very silty and impure limestone or calcareous siltstone that may be referable to the Alto overlies the Lingle limestone along Clear Creek in the NE. ¼ sec. 34, T. 11 S., R. 2 W., crops out by the roadside in the NW. ¼ sec. 1, T. 13 S., R. 2 W., underlies the Springville shale (the black shale is absent) along a tributary of Dutch Creek near the south line of the same section and in the NW. ¼ of the adjoining sec. 12, and occurs along a tributary of Cooper Creek in the SE. ¼ NE. ½ sec. 2, T. 14 S., R. 2 W.

Along the eastern margin of the Devonian area south of Jonesboro neither the Grand Tower limestone nor the Mountain Glen shale are present and with the exception of the localities already mentioned the strata intervening between the Dutch Creek sandstone and the Springville shale consist of shaly, silty and siliceous beds that are for the most part much leached and altered from their original condition. Locally, as in the SW. ¼ sec. 26 and NW. ¼ sec. 35, T. 13 S., R. 2 W., fossiliferous limestone of the Lingle type is present, and Savage applied the name Misenheimer shale to the underlying argillaceous strata. Throughout this area, however, the upper Devonian beds are greatly disturbed. Small faults are abundant, the direction of strike changes rapidly, and dips vary greatly both in amount and direction with many reversals. Consequently the working out of any general stratigraphic section has proved to be impossible and the recognition of Savage's three formations or any other consistent subdivisions of this section is impracticable. Lithologically some parts of this section are very similar to the Mississippian Springville shale and it is not certain that this formation has been correctly distinguished from the Devonian beds at all localities.

In a general way the lower part of the post-Dutch Creek Devonian section of this area was originally less calcareous and more argillaceous than much of the upper part. It probably consisted largely of silty poorly bedded bluish-gray shale that, as now visible in outcrops, is weathered to a buff or drab color. Some zones near the base contain abundant impressions of a very few species of fossils. Such beds may be seen beside the road in the SW. ¼ sec. 26, T. 13 S., R. 2 W. Shale of similar type but less fossiliferous and possibly occupying higher stratigraphic positions crops out along the creek in the NE. ¼ sec. 11 of the same township.

Limestone with abundant Lingle fossils crops out in a more or less tumbled condition at a few places in the southern part of T. 13 S., R. 2 W. Different beds vary greatly in lithology. The most conspicuous type is massive fine-grained dark gray siliceous limestone whose weathered surface is characterized by large crinoid stem segments and which carries irregular nodules of chert. Other strata are light brownish-gray and apparently dolomitic with fossils preserved as casts. The more impure limestone layers are generally completely leached and decomposed.

The upper and probably the greater part of the post-Dutch Creek Devonian succession has been observed nowhere south of Jonesboro in unweathered condition. In its outcrops it resembles both the shale below the limestone with Lingle fossils and some phases of the Springville shale. Although some shale is present much of this material was originally more or less calcareous and it crops out as siliceous argillaceous and silty minutely porous beds of buff or drab colors. A few strata are dark chocolate brown with local green tints and are obviously much altered from their original condition. Bedding is generally good and the layers vary in thickness from two to ten inches. Fossils are rare. Dark colored chert occurs locally in more or less continuous beds, and large irregular tabular chert

nodules with rounded surfaces—weathered white but olive-brown inside—occur along some of the stream courses. One of the best places to observe these beds is a bank on the east side of a tributary to Lingle Creek near the center of the NW. ¼ sec. 23, T. 13 S., R. 2 W. They are also well exposed in the SW. ¼ SW. ¼ sec. 13 of the same township.

Because of their disturbed structural condition, estimation of the thickness of these upper Devonian beds is difficult and uncertain if not impossible. The records of wells drilled a short distance east of their zone of outcrop suggest, however, that they total about 200 feet although this thickness may diminish considerably to the south.

The Grand Tower limestone thins southeastward as previously mentioned and is not known to crop out south of the latitude of Jonesboro although the Dutch Creek sandstone which conformably underlies it extends to the edge of the Cache River bottoms south of Elco. The Grand Tower (1) may never have been deposited in the southern part of this area, (2) it may have been removed by subsequent erosion, (3) it may grade southward into shale, or (4) it may have been completely leached and removed by solution to below the present drainage level. Choice between these four alternatives is difficult because of inadequate evidence.

It is likely that Grand Tower limestone or strata of different lithology but similar age were deposited in southern Union and Northern Alexander counties, inasmuch as the limestone as far south as it is known in outcrops gives no indication of littoral or near littoral accumulation. It is possible that the Grand Tower limestone passes southward into shale of the Misenheimer type, but if so the transition must be quite abrupt and fully accomplished within a very short distance. The Lingle limestone of northern Union County, however, is impure and includes a considerable proportion of argillaceous strata and it appears more likely, therefore, that shale of the Misenheimer type is a lateral gradation of this part of the section rather than of the Grand Tower limestone.

An unconformity probably separates the Grand Tower and Lingle limestones in southern Jackson County, and the thinning of the former formation in a southeastward direction suggests that an important interval of erosion may have occurred. The conclusion that this erosion completely removed the Grand Tower south of Jonesboro, however, is questionable because it is unlikely that erosion of such magnitude would have ceased uniformly at the thin and rather friable Dutch Creek sandstone. On the other hand this possibility cannot be entirely dismissed for it may be that the boulders of sandstone (actual outcrops are rarely observable) are residual remnants of the Dutch Creek that were preserved on this Devonian land surface and that they were subsequently incorporated in succeeding sediments.

In some ways the suggestion that the Grand Tower limestone south of Jonesboro has been completely leached and removed by solution to beneath the level of the present drainage is the most satisfactory, although actual substantiating evidence is lacking. As has been previously mentioned, the general absence of limestone from the Devonian section south of State Highway No. 146 is believed to be related to leaching and alteration of the formations to a depth of about 400 feet below the post-Eocene peneplain that dips gently toward the south. The Grand Tower is for the most part an unusually pure limestone highly susceptible to solution as is shown by the sink-holes which mark its outcrops in northern Union County, and it is therefore conceivable that it might be entirely dissolved away. If this explanation is correct it would also account for the highly disturbed state of the younger Devonian strata which would be much broken and contorted as the result of unequal settling and collapse during the time that the underlying limestone was being removed. It is perhaps significant that these beds are so disturbed in that part of the area where the Grand Tower limestone fails to crop out.

Mountain Glen shale.—This formation attains a maximum thickness of about 50 feet and consists of hard well-laminated black carbonaceous shale of the Chattanooga type. Its complete thickness may be observed just below the spillway of the dam at the State Pond in S. ½ sec. 14, T. 12 S., R. 2 W. A good outcrop is also present in the south bank of Darty Creek in the SE. ¼ sec. 10 of the same township. The probably unconformable contacts of this formation with the overlying Springville shale

and underlying Alto limestone are exposed at these two places. Smaller outcrops occur in gullies on the west sides of Iron Mountain in sec. 34, T. 11 S., R. 2 W., and a similar ridge north of Clear Creek in sec. 27 and near the center of the NW. ¼ sec. 29, T. 12 S., R. 2 W. No outcrops of Mountain Glen shale are known between Jonesboro and Elco and it is believed to be absent throughout most of this area, as near the middle of the south line of sec. 1, T. 13 S., R. 2 W., Springville shale directly overlies very impure limestone referred to the top of the Alto formation. It reappears to the south, however, for there is a small outcrop of black shale by the roadside near Elco in the NW. ¼ SE. ¼ sec. 18, T. 14 S., R. 1 W., and other exposures occur in the neighboring part of the Dongola quadrangle just to the east.

The Mountain Glen shale corresponds to part of the dark *Sporangites*-bearing New Albany shale of Upper Devonian or Lower Mississippian age which is persistently developed to a thickness of about 200 feet throughout the Illinois basin.

Mississippian System

The Mississippian system thins considerably from the Dongola quadrangle westward into the Alto Pass and Jonesboro quadrangles. This thinning affects almost all of the formations but is most important in the pre-Chester limestone succession. During the Mississippian period northwestern Union County and an area of unknown extent farther south apparently constituted the border of the Ozark region of Missouri and northern Arkansas. It failed to subside to the same extent as the Illinois basin and possibly was periodically uplifted, and these conditions were reflected in the lesser amount of sediment deposited in this area. These movements were slow and probably persisted somewhat unequally throughout the Mississippian period. There is no progressive overlap of the lower formations, for so far as known the Springville shale is everywhere present at the base of the system.

Springville shale.—This formation is about 60 feet thick and unconformably overlies the black Mountain Glen shale or, where that is absent, impure limestone of the Alto formation. It consists mainly of more or less greenish nonfossiliferous shale that is argillaceous in the lower part but becomes increasingly silty and siliceous above. The entire formation is exposed in the east bank of the creek in the center of the S. ½ sec. 1, T. 13 S., R. 2 W. Other good exposures occur in an old quarry south of State Highway 146 in the NE. ¼ sec. 23, T. 12 S., R. 2 W., in the bank of Darty Creek in the SE. ¼ sec. 11, and along the road south of Jonesboro near the center of sec. 36, in the same township. Dark red shale appears locally in the lower part of the formation, and near its base northwest of Jonesboro is a discontinuous layer of fossiliferous impure greenish mottled gray limestone a foot or more thick. The upper part of the formation becomes harder and thicker-bedded but is rarely exposed in an unweathered condition. These strata may be best observed in the creek bed in the SE. ¼ SW. ¼ sec. 13, T. 13 S., R. 2 W. where they are bluish-gray, very fine-grained, and look like thin-bedded limestone but do not effervesce when treated with acid.

The lower part of the Springville shale commonly weathers to a somewhat greenish-buff color, not unlike some of the underlying Devonian strata. The upper more siliceous part is altered at almost all of its outcrops to the material known locally as "calico rock." This is hard, somewhat porous, more or less cherty, and well-bedded in layers two inches to a foot thick which are closely jointed into small rhombohedral blocks. It has been quarried in a small way at many places for use in rough masonry. It is ashy gray in color and has received its name from the peculiar red and brown iron-staining along fractures and in concentric bands parallel to some of the joints. The "calico rock" is best developed in the southern part of T. 13 S., R. 2 W., where it commonly attains a thickness of 10-20 feet. It is very resistant to further weathering and erosion and constitutes an important part of the float along the creeks which cut its outcrops. Good exposures occur along Lingle Creek in the NE. ¼ sec. 26, of this township.

Hartline chert.—The best development of the Hartline chert occurs in the southwestern part of the Dongola quadrangle, and excellent outcrops are present in the face of the bluff west of Ullin in sec. 21, T. 14 S., R. 1 W. Here it is about 50 feet thick and consists of massive gray novaculitic chert in well-defined beds a foot or more thick. This chert appears to thin and

change in character northwestward. Near the center of sec. 18 of the same township it is about 30 feet thick. Bedding is less conspicuous and the chert appears very massive but it is minutely shattered and some parts are quite friable. Farther to the north and west typical Hartline chert has not been recognized but it is believed to be represented by the "ganister" beds that have been mined near the center of the N. ½ sec. 18 T. 14 S., R. 1 W., and at the center NE. ¼ sec. 1, T. 14 S., R. 2 W. The "ganister" of this district is white very friable cherty material similar to the "tripoli" of the Clear Creek chert but more granular.

The Hartline chert appears to overlie the Springville shale unconformably. This contact is exposed near the center of sec. 18 and in the SW. ¼ NW. ¼ sec. 21, T. 14 S., R. 1 W. At both places the contact with the "calico rock" is sharp. At the former it is somewhat uneven and at the latter it is marked by glauconitic material. The relation of Hartline chert to overlying beds is not known as their contact has nowhere been observed. The general succession of strata in several outcrops along the bluff west of Ullin suggests that the Hartline chert grades upward into cherty Osage limestone.

Lower Mississippian limestone.—The Burlington, Keokuk, Warsaw, and Salem limestones of the standard Mississippian succession have not been differentiated in the Jonesboro and Alto Pass quadrangles. In the Dongola quadrangle just to the east, Mississippian limestone below the St. Louis may be divided into two parts equivalent to the Burlington-Keokuk and Warsaw-Salem formations respectively, but even this distinction cannot be readily made in the Jonesboro and Alto Pass quadrangles. The disappearance of the Hartline chert northward, the general absence of strata similar to the Burlington-Keokuk limestone of the Dongola quadrangle, and the apparent thinning of the pre-St. Louis strata all suggest that the lower Mississippian limestones progressively overlapped upon the Springville shale. If this interpretation is correct, the situation in the Jonesboro and Alto Pass quadrangles is unique for no comparable overlap of beds of this age is known anywhere and no deformation of this age capable of producing the requsite amount of uplift has been recognized elsewhere. Doubt is thrown upon this explanation by the fact that the Springville shale has not been noticeably attacked by erosion or thinned in the northern part of the area where the overlying Mississippian limestone is apparently thinnest. Consequently it is possible that a different interpretation of these relations might be made were additional evidence available.

The lower Mississippian limestone of the Alto Pass and Jonesboro quadrangles is mostly light gray, finely granular, and very siliceous but includes little chert in unweathered outcrops. Its character changes gradually from the bottom to the top where it grades conformably into the St. Louis limestone. A little dark gray chert is present at the base, either in a few thin bands or flattened nodules, and glauconitic shale occurs locally. Contact with the Springville shale has been seen only beside State Highway 146 in the NE. ¼ NE. ¼ sec. 23, T. 12 S., R. 2 W. The lower part of the limestone is there bluish-gray, dense and homogeneous, but more commonly this part is light gray and granular with small brownish calcite crystals, probably broken crinoidal fragments, in a dense matrix. It is mostly thin-bedded and slabby but along the creek banks it may spall off in thin plates parallel to the surface of exposure. Beds of this type are well exposed along the creek which parallels the railroad in the SE. ¼ sec. 1, T. 13 S., R. 2 W., and NW. ¼ sec. 7, T. 13 S., R. 1 W. Fossils are very rare and consists mostly of a few medium-sized crinoid stem segments. In the upper part of this succession the dense matrix between the crystalline calcite granules becomes lighter colored and some beds near the top are almost white. Such strata are locally crowded with the broken fronds of bryozoans, and associated strata are coarsely granular with abundant but mostly dismembered crinoid plates. Limestones of these types may be seen near the center NE. ¼ sec. 11, T. 12 S., R. 2 W. Oolitic beds likewise occur at a few places.

Much of the lower Mississippian limestone is highly siliceous, but the silica is mainly disseminated throughout the rock rather than segregated in beds or nodules of chert. Dark gray very siliceous limestone is well exposed by the roadside in the NW. ¼ SW. ¼ sec. 30, T. 13 S., R. 1 W. This outcrop is close to the base of the limestone and perhaps represents the zone of the

Hartline chert which may become progressively less siliceous to the north and grade into the type of limestone described above. Weathering has resulted in the removal of calcium carbonate by solution and in the concentration of the silica in the residuum derived from the limestone. This residuum is quite characteristic and consists of bright red more or less coarsely porous cherty material that preserves the bedding of the original limestone but breaks down readily into fine red chert rubble. It is well exposed at numerous places along the road between Jonesboro and Elco where the nearby hillsides have been stripped of soil to form the road embankment. This material was formerly worked in large pits in the NE. ¼ NW. ¼ sec. 18, T. 14 S., R. 1 W., and road "gravel" is now being obtained from a pit on the south side of Lingle Creek in the SW. ¼ sec. 30, T. 13 S., R. 1 W. This residuum is so different in appearance from the original limestone that their connection is not obvious, but their relations are clearly shown at a large artificial exposure near the center SW. ¼ sec. 19 of the same township.

The thickness of the outcropping lower Mississippian limestone is very difficult to estimate because of variable dips and incomplete exposures. The combined thickness of the Burlington-Keokuk and Warsaw-Salem limestones in the Dongola quadrangle was estimated by Krey to be about 500 feet, but this is believed to be too great a figure for the Alto Pass and the northern part of the Jonesboro quadrangles. On the other hand Poor's estimate of 100 feet (all referred to the Salem) for the Alto Pass quadrangle appears to be too small. It is possible that in the latter area unrecognized strike-faulting has resulted in an important reduction in the width of outcrop of this limestone.

St. Louis limestone.—The St. Louis limestone consists of hard dark bluish-gray very fine-grained to sublithographic beds with inter-stratified more coarsely crystalline layers. Fossils are not abundant, but locally corals are conspicuous on weathered surfaces and in the residuum. No oolite has been observed, but chert is more or less abundant throughout the limestone. The chert is dark colored and occurs in nodules or thin discontinuous bands. A zone in the upper part of the formation carries spherical nodules up to a size of about four inches in diameter. Good exposures of the St. Louis limestone occur at intervals along Kratzinger Hollow north of Jonesboro in sec. 18, T. 12 S., R. 1 W., and in the adjoining sec. 13 in the next township. The St. Louis limestone is conformable with the overlying and underlying formations and probably attains a thickness of between 200 and 300 feet, thinning northwestward along its strike.

Ste. Genevieve limestone.—Farther east in southern Illinois the Ste. Genevieve formation is subdivided into the following members:

4. Hoffner member
3. Levias limestone
2. Rosiclare sandstone
1. Fredonia limestone

The Rosiclare sandstone and Levias limestone have not been certainly identified in the Alto Pass and Jonesboro quadrangles. Either or both of these members may be absent or may have changed laterally to such an extent that it or they are unrecognizable. The upper Ste. Genevieve strata are not particularly well exposed in northwestern Union County and consequently their precise correlation is somewhat uncertain. It seems most likely, however, that the Rosiclare sandstone is undeveloped or is represented by an inconspicuous sandy zone in the limestone. If so, the Fredonia and Levias limestone members are both included in that part of the section that is here termed the Ste. Genevieve limestone.

The Ste. Genevieve is generally lighter colored and less cherty than the St. Louis. Dense dark gray limestone alternates irregularly with light gray crystalline layers. The Ste. Genevieve is characteristically oolitic and beds of very pure white oolite occur which are most prominent in the upper part. Chert is most common in the lower part of the limestone but is also present more or less sporadically at higher horizons although it is confined mainly to the darker and finer-grained layers. Some of the limestone is strongly cross-bedded. The thickness of the St. Genevieve limestone at its outcrop in the Alto Pass quadrangle has been estimated at about 150 feet. This is less than half of the estimated thickness in the neighboring Dongola quadrangle. There is no sharp break between the Ste. Genevieve and St. Louis limestones and the

boundary is generally drawn just beneath the lowest oolitic beds. The Ste. Genevieve limestone likewise appears to be succeeded conformably by the Hoffner beds.

The Hoffner member of the Ste. Genevieve formation consists principally of sandstone. Most of it is shaly although resistant but thin-bedded strata occur in the upper part. Well-laminated silty conspicuously variegated shales of red, green, and ochreous colors are characteristic of the lower part. More calcareous layers or thin impure limestone beds are locally present. This member averages about 30 feet in thickness but probably thickens considerably along its outcrop in the extreme southeastern part of the Alto Pass quadrangle.

Renault and Paint Creek formations.—The Renault and Paint Creek formations have not been differentiated in the Alto Pass quadrangle because of the absence of the Bethel sandstone which separates them to the east. They consist of interbedded limestone and shale. The limestone is gray, more or less crystalline, of variable lithology, and the shale is partly calcareous and partly variegated in purple, red, and ochreous colors. They commonly attain a combined thickness of about 45 feet and are separated by unconformities from the adjacent beds both above and below.

Cypress sandstone.—The Cypress is a fine-grained brown sandstone that is commonly rather massively bedded. South and southeast of Alto Pass it is sufficiently resistant to erosion that it caps a series of cuesta-like hills. Its thickness here is about 50 feet and the upper part is locally very fossiliferous. The Cypress thins and becomes more shaly northwestward along its outcrop, and in the bluffs near Big Muddy River it is reduced to a thin inconspicuous sandy zone.

Golconda limestone.—The Golconda includes much limestone in more or less massive layers separated by shale. The limestone varies considerably in character but is generally gray to buff in color and crystalline. Some beds are very fine-grained and dense and others are oolitic, but these types of strata make up only a small part of the formation. The shales are commonly grayish and more or less calcareous, but greenish and black shales are also present. The Golconda attains a maximum thickness of about 60 feet. It overlies the Cypress sandstone conformably but is probably separated from the overlying Hardinsburg sandstone by an unconformity.

Hardinsburg sandstone.—The Hardinsburg is a fine-grained brown conspicuously cross-bedded sandstone. Where best developed the lower 10 to 15 feet is very massive and forms small hogback ridges. The upper part of the formation is thin-bedded and shaly, and the lower massive member locally grades laterally and abruptly into shaly beds. This formation attains a maximum thickness of about 40 feet but apparently thins to the west, becomes more shaly, and has not been mapped beyond sec. 17, T. 11 S., R. 2 W.

Glen Dean limestone.—The Glen Dean consists of a variable succession of limestone beds separated by shale. Much of the limestone is gray, crinoidal, and highly crystalline. It probably includes less dense fine-grained limestone than any other Chester formation. The shale members are generally gray and more or less calcareous. This formation is about 40 feet thick. It overlies the Hardinsburg sandstone conformably but is probably separated from the overlying Tar Springs sandstone by an unconformity.

Tar Springs sandstone.—The Tar Springs is the most uniform of the Chester sandstones of the Alto Pass quadrangle. It is everywhere more or less massive and forms many bluffs. Cross-bedding is remarkably developed and ripple-marked surfaces are abundant. It is approximately 75 feet thick.

Vienna limestone.—The Vienna differs from all of the lower Chester limestones and is similar to all of the higher ones in being composed of generally darker colored finer-grained and more cherty limestone layers which weather to smooth rather than rough surfaces. The Vienna is the most cherty of the Chester formations. Locally it is mainly limestone but at some places it grades laterally into calcareous shale. It overlies the Tar Springs sandstone conformably and may be likewise succeeded conformably by the Waltersburg sandstone. The Vienna limestone probably does not exceed 30 feet in thickness, and west of Alto Pass, where the Waltersburg sandstone is thin and too shaly to be identified, the Vienna has generally not been distinguished from the Menard.

Waltersburg sandstone.—The Waltersburg sandstone is commonly thin-bedded

and shaly, but locally there are more massive layers that form small bluffs. At its base or at the top of the Vienna are a few thin layers of sandy fossiliferous limestone. The Waltersburg sandstone may reach a maximum thickness of 45 feet but it thins out and becomes more shaly to the west and has not been mapped far beyond Alto Pass.

Menard limestone.—The Menard is the most uniform of all the Chester formations. It is composed mainly of dark fine-grained massively bedded limestone with some intercalated shale. A few richly oolitic beds have been observed and some chert is present. It reaches a thickness of about 90 feet, overlies the Waltersburg sandstone conformably, but may be separated from the overlying Palestine sandstone by an unconformity.

Palestine sandstone.—The lower part of the Palestine sandstone is generally quite shaly with only a few thin beds of sandstone. The upper part consists of somewhat cross-bedded and ripple-marked sandstone in beds 4 to 10 inches thick. Some variegated sandy shale occurs in the lower part of the formation, and locally near the top there is an inch or two of impure coal. This formation maintains a rather uniform thickness of about 30 feet except where it has been cut into or removed by pre-Pennsylvanian erosion.

Clore limestone.—The Clore consists of shaly limestone in beds two to six inches thick separated by partings or layers of shale. The limestone characteristically weathers into thin flakes. This formation probably nowhere exceeds 40 feet in thickness. It is believed to succeed the Palestine sandstone conformably and to be unconformably overlain by the Degonia sandstone.

Degonia sandstone.—The Degonia is, with the possible exception of the Tar Springs, the most massive Chester sandstone of the Alto Pass quadrangle and forms sheer bluffs or cliffs as much as 40 feet high southeast of Alto Pass. It is much cross-bedded and many layers are ripple-marked. This formation closely resembles the massive Pennsylvanian sandstones of the Caseyville group with which it has been more or less confused in the past and from which it can be certainly distinguished only where the intervening Kinkaid limestone is present or by the complete absence of small quartz pebbles. The Degonia sandstone attains a maximum thickness of about 75 feet.

Kinkaid limestone.—The Kinkaid is mainly rather massively bedded limestone. It is commonly dark gray and fine-grained but includes some crystalline layers. Chert occurs in the lower part. This formation overlies the Degonia sandstone conformably. It probably nowhere exceeds 50 feet in thickness and over considerable areas has been completely removed by pre-Pennsylvanian erosion.

Pre-Pennsylvanian Unconformity

The unconformity at the base of the Pennsylvanian system is the most important in the Paleozoic sequence of Illinois and represents a considerable interval of time during which no sediments accumulated and erosion was active. During this time warping of the rocks occurred extensively, but the Alto Pass quadrangle is one of the very few places where this warping is known to have been accompanied by faulting. Erosion of the warped and faulted Mississippian rocks in the Alto Pass quadrangle resulted in the overlap of the basal Pennsylvanian beds upon various Chester formations as old as the Menard limestone.

Pennsylvanian System

The Pennsylvanian strata of the Alto Pass quadrangle have not been studied. In neighboring areas, however, the lower part of this system is divided into the Caseyville group below and the Tradewater group above, both of which are much thicker and more completely developed some distance to the east. The Caseyville group is dominated by two fairly thick and persistent massive cliff-forming sandstones which are characterized by scattered small rounded quartz pebbles. These sandstones are separated, overlain and underlain by more or less sandy shales which carry a few thin and discontinuous coal seams. The several sandstones of the Tradewater group are generally much less resistant than the Caseyville sandstones and the intervening shales include several coal seams a few of which, although thin, are quite persistent. Thin limestones are present at more than one horizon in the upper part of this group. The Caseyville group is probably not more than 250 feet thick in the Alto Pass quadrangle. The Tradewater group is probably thicker but no reasonably accurate estimate can be made from the inadequate data now available.

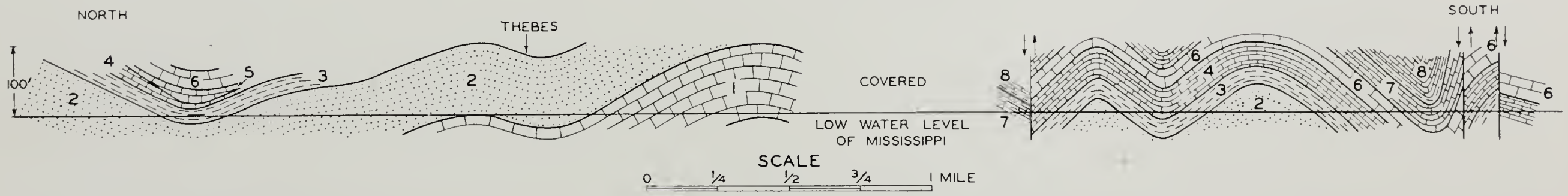

FIG. 2.—Structure section along east side of Mississippi River near Thebes.

1 Kimmswick limestone
2 Thebes sandstone
3 Orchard Creek shale
4 Girardeau limestone
5 Edgewood limestone
6 Sexton Creek limestone
7 Bainbridge limestone
8 Bailey limestone

Cretaceous and Tertiary Deposits

Mainly unconsolidated sands, clays, and gravels of Cretaceous and Tertiary age overlap the Paleozoic rocks from the south. They underlie much of the upland area southwest of State Highway No. 3 between Thebes and Olive Branch but scattered outliers occur at least as far north as the Alto Pass quadrangle. These beds rarely crop out in natural exposures and may be best observed in several cuts along the Missouri Pacific Railroad between Thebes and Fayville.

STRUCTURE

The structure of the quadrangles considered in this report is complicated and reflects movements that occurred at several different times during the geologic past. The most prominent features are: (1) The Rattlesnake Ferry monocline and fault-zone which crosses from Missouri to Illinois a short distance north of Grand Tower, intercepts the bluffs adjacent to Big Muddy river just below Rattlesnake Ferry, and extends southeastward between Alto Pass and Bald Knob; (2) the Harrison Creek anticline which follows a somewhat sinuous course from Bald Knob southward into Alexander County.

The Rattlesnake Ferry structure is an abrupt, steep, and narrow monocline dipping to the northeast which is broken by subordinate faults. In the southeastern part of the Alto Pass quadrangle it widens and passes into the general regional northeastern dip toward the Illinois basin. Relative displacement accomplished in little more than a mile by both folding and faulting amounts to a maximum of about 2000 feet. Of this amount less than half is the direct result of faulting. The faults are rarely exposed but their existence is demonstrated by the absence of several formations along the monoclinal zone and the offsetting of the linear outcrops of other formations. Steeply dipping beds are exposed at many places along this zone. The greatest dip observed is 70° but dips of 20° to 30° are common. This structure is similar in many ways to the Cap-au-Grés monocline and fault-zone of Calhoun and Jersey counties and like it probably originated in post-Mississippian—pre-Pennsylvanian time and has subsequently been accentuated.

The Harrison Creek anticline begins just south of the Rattlesnake Ferry monocline and fault-zone at Bald Knob. This hill, the highest point in southwestern Illinois, probably owes its existence to the combination of an uparching of the rocks and the local presence of unusually massive chert beds in the upper part of the Clear Creek formation. This structural axis is plainly revealed along Clear Creek, where the Backbone limestone is brought above drainage, and its presence is shown along Caney and Green creeks by the occurrence of Grand Tower limestone and Dutch Creek sandstone at relatively low elevations near Morgan School. South of Dutch Creek the axis of the anticline appears to be broken by the Atwood fault, for Bailey limestone crops out on one side but only Clear Creek chert has been observed upon the other. A little farther south the Atwood fault swings southeastward, diverging from the anticlinal axis which is perfectly shown along Harrison Creek by an arch in the Girardeau limestone beneath which Orchard Creek shale appears in a small area. Dips on both flanks of the structure are exposed in the valley of Ubedam Creek, and Silurian limestone is brought well above drainage level. Farther south the anticline appears to swing to the southeast, decrease in magnitude, and about two miles west of Elco joins the plunging northeastern extremity of the Thebes anticline. The Harrison Creek anticline is probably asymmetrical with steeper dips to the east. It bears an elongated dome whose highest point is at or near its intersection with Harrison Creek, and a somewhat smaller dome occurs in the vicinity of Bald Knob.

The Harrison Creek anticline probably originated before the beginning of the Pennsylvanian period and is also believed to antedate the first development of the Rattlesnake Ferry monocline but was much accentuated south of the intersection of these structures in post-Pennsylvanian time. This is indicated by the suggestion of a northward plunging arch in Chester strata north of Bald Knob and west of Alto Pass and the removal of several of the upper Chester formations by pre-Pennsylvanian erosion in this area. It is possible that the Harrison Creek anticline is a southward extension of the DuQuoin anticline. These are both north-south structures east of which occurs

remarkable thickening of the stratigraphic section. If these structures are connected, movement appears to have originated at the southern end of their combined axis and slowly progressed northward, for the Mississippian formations thicken greatly to the east of the Harrison Creek anticline but thickening on the flank of the DuQuoin anticline appears to be confined entirely to the Pennsylvanian system.

The Harrison Creek anticline is bounded on the west by the Pottsville syncline. This structure is broad and indistinct north of Dutch Creek but rapidly deepens to the south, and 2¼ miles east of Ware contains an outlier of basal Mississippian strata. South of here its axis is concealed beneath alluvium of the Mississippi River bottoms but must pass close to the tiny hamlet of Pottsville. This syncline reappears in the bluffs southeast of Reynoldsville and swings gently to the southeast toward Delta where its axis is marked by outliers of Dutch Creek sandstone. It is here broken by the parallel Delta fault.

An anticlinal nose plunging to the southeast is apparent in the bluffs east of McClure. This is probably the southeastern extremity of a structure, mainly hidden beneath Mississippi River alluvium, which connects with a structurally high area on the west side of Mississippi River in Missouri.

The Thebes anticline and its bounding synclines are rather poorly defined structures which all plunge to the northeast. The highest point on the Thebes anticline is in the bank of the Mississippi River about half a mile below the railroad bridge at Thebes (fig. 2). It is not known to what extent this structure persists or continues to rise westward in Missouri.

Small faults are rather abundant in most parts of the Alto Pass, Jonesboro, and Thebes quadrangles but during the recent restudy of the pre-Mississippian formations no attempt was made to map them except where they appeared to produce important offsets in the formation boundaries. Several that are best exposed are obviously thrust faults and it is probable that most of the structure of these quadrangles, including the Rattlesnake Ferry monocline and fault-zone and the Harrison Creek anticline, were produced by compressional forces that affected the border of the Ozark region.

Complicated and unusual structural conditions are shown by the outcrops along Cave Creek and its tributaries south of Pomona. Chester strata are broken by several small faults and locally dip steeply but are overlain by undisturbed Pennsylvanian strata.[13] These relations clearly demonstrate the existence of a period of post-Mississippian, pre-Pennsylvanian disturbances. Probably other structural irregularities observed in the pre-Mississippian area to the south were produced at this same time.

[13]St. Clair, Stuart, Oil investigations in parts of Williamson, Union, and Jackson counties: Illinois Geol. Survey Bull. 35, p. 53, 1917.

Ekblaw, G. E., Post-Chester, pre-Pennsylvanian faulting in the Alto Pass area: Illinois Acad. Sci. Trans., vol. 18, pp. 378-382, 1925.

N — "MOMENTUM" MISSISSIPPI

S — ST. LOUIS

F — FREDONIA

US — UPPER STE. GENEVIEVE

R-R — RENAULT AND PAINT CREEK

KY — CYPRESS

C — COLCONDA

H — HARDINSBURG

CD — GLEN DEAN

T — TAR SPRINGS

V — VIENNA

ALEXANDER UNION

THEBES

KIMMSWICK

KM

U-1

STATE OF ILLINOIS
JOHN STELLE
DEPARTMENT OF REGISTRATION AND EDUCATION
JOHN J. HALLIHAN, Director

GEOLOGICAL SURVEY DIVISION
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URBANA

REPORT OF INVESTIGATIONS No. 70, PLATE I

R 3 W | R 2 W | R 1 W

T 10 S | T 11 S | T 12 S | T 13 S | T 14 S | T 15 S | T 16 S

ALTO PASS | JONESBORO | THEBES

MAPPING INCOMPLETE

JACKSON CO.
UNION CO.
UNION CO.
ALEXANDER CO.

LEGEND

AI	ALLUVIUM
CR	CRETACEOUS
PENN	PENNSYLVANIAN
K	KINKAID
D	DEGONIA
C	CLORE
P	PALESTINE
M	MENARD
W	WALTERSBURG
V	VIENNA
T	TAR SPRINGS
GD	GLEN DEAN
H	HARDINSBURG
G	GOLCONDA
CY	CYPRESS
P-R	PAINT CREEK AND RENAULT
US	UPPER STE. GENEVIEVE
F	FREDONIA
SL	ST. LOUIS
LM	"LOWER MISSISSIPPIAN"
S-M	SPRINGVILLE AND MOUNTAIN GLEN
L-A-M	LINGLE, ALTO, AND MISENHEIMER
G-C	GRAND TOWER AND DUTCH CREEK
CC	CLEAR CREEK
BB	BACKBONE
GK	GRASSY KNOB
BL	BAILEY
B-S	BAINBRIDGE AND SEXTON CREEK
GR	GIRARDEAU
O-T	ORCHARD CREEK AND THEBES
KM	KIMMSWICK

SCALE
0 1/2 1 2 3 MILES

PRELIMINARY GEOLOGIC MAP OF PARTS OF THE ALTO PASS, JONESBORO, AND THEBES QUADRANGLES

(REVISED IN PART FROM MAP BY T. E. SAVAGE)

By J. MARVIN WELLER AND GEORGE E. EKBLAW

1940